

water covers itself with drifting clouds of so-called steam. There are doubtless surface fogs which correspond to this condition, though when the evaporation is very rapid there may be, as Mr. C. T. R. Wilson has shown, a clear layer immediately in contact with the water surface. Fogs which have their origin in this mixture of the rising vapour with cooler air may be called "steaming water fogs." On the other hand, if any surface is sufficiently cold the absorption of heat from the air in contact with it may cause condensation in the air close to the surface, and fogs arising in this way may be called, for the sake of brevity, "cold-surface fogs." Vigorous radiation such as takes place on a clear night from grass may cause a fog of this character, and in regard to the persistence of a fog under these circumstances the transparency, or rather translucence, of fog for radiation is an important but not well-known factor. In these cases the source of the water supply is easily identified as being the water surface in the one case and the air in contact with the surface in the other.

Clouds, consisting of more or less detached masses of fog formed in either of these two ways, may drift like the steam from a locomotive or a sea fog over land, and a fog may thus visit a locality which has had no share in supplying the water. There is, moreover, another possibility which may be connected with the question as to why fogs are more prevalent in winter than in summer, in spite of the fact that the store of moisture in the air is larger and changes of temperature are more pronounced in the warmer months. Rain has been defined as a falling cloud which reaches the surface before the evaporation of the globules is complete. The rate of fall depends on the size of the particles, but in still atmosphere even the smallest particles make their way downward. In summer the falling cloud may consist of anything between a thunder shower and drizzling rain. In winter, when the supply of moisture is less and, over towns, the supply of nuclei for condensation is greater, the counterpart of the summer drizzle may be so light as to be classed as fog or mist, and fall with extreme slowness. In this case the water supply comes from strata above the surface. There are certainly some fogs in which there seems to be a gradual deposit of moisture on horizontal surfaces, and not merely on specially cold surfaces. It is true that winter fogs are often associated with high barometric pressure, generally a fine weather association, but under similar conditions of pressure very light rainfalls on our eastern and northern coasts are sometimes experienced. Whether electrical conditions, which are exceptional in foggy weather, may account for the formation or accelerate the falling of the cloud in such circumstances I cannot say.

If we call this third form of fog, due either to the surface drifting or the downward descent of a cloud formed above the surface, a "cloud fog," we have altogether three forms—"steaming water fogs," "cold-surface fogs" and "cloud fogs." It is evident that, of these three, two depend upon local conditions which may possibly be identified, while the third is at least much more independent of local conditions and its incidence may be as capricious as the summer cloud.

The consideration of the observations from this point of view requires more than mere organisation. It involves a special knowledge of the physics of the atmosphere applied to observations of a somewhat special kind, and may need some appropriate apparatus. It is hoped that circumstances will allow the statistical investigation to be combined with the consideration of such physical questions as those which I have indicated; but the time for arrangement is short, and it is possible that the physical side of the investigation may have to wait for a more favourable opportunity. The primary consideration at present is the suitable organisation of trustworthy observations.

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## ALUMINIUM AND ITS USES.

THE number of metals available in large quantities for industrial purposes is so very small, that the successful introduction of a new one must be of the greatest interest. The affinity of aluminium for oxygen much exceeds that of iron at a red heat. Iron oxide is reduced by carbon at that temperature, while alumina cannot be reduced in this way except in the electric arc. And thus, though the ores of aluminium are more widely distributed even than those of iron, yet the former metal remained for long unknown, and until lately was comparatively rare.

About fifty years ago, the researches of Wöhler and Deville led to the latter's process for the production of aluminium on a commercial scale, in which the vapour of aluminium chloride was led over heated sodium. The price of the new metal fell rapidly, but was always high and dependent upon that of sodium.

In 1854, Bunsen and Deville showed independently that aluminium could be obtained by electrolysis from a bath containing the chlorides of both aluminium and sodium in a state of fusion, the latter chloride acting merely as a flux. But at that time the cost of electrical energy was prohibitive.

The first successful electrical process was that of Cowles, in which alumina is reduced by carbon in the electric furnace. It rapidly superseded the old chemical method, in spite of the reduction in the price of sodium by the Castner process, but had soon in its turn to give place to the processes of Hall and Héroult discovered in 1886 (though not successfully worked until some years later). In these, a bath of the fused fluorides of aluminium and sodium is employed. They occur naturally combined as cryolite; and serve, when melted, as a solvent for alumina, which by itself would, of course, be almost infusible. The alumina is electrolysed by a current introduced at a carbon anode, and further alumina is added as the metal collects at the other pole. The bath must be maintained at a red heat, and an electromotive force of somewhere about five volts is needed.

It is this process which has brought down the cost of aluminium so much of late. Other methods, as those of Blackmore and Gooch, depending upon the preparation and subsequent electrolysis of fused aluminium sulphide, are said to be yet more economical, the sulphide being much more readily decomposed than the oxide. But the saving in electrical energy does not yet seem to make up for the greater expense of working materials.

The cost of water-power, even in situations offering great natural advantages, cannot be indefinitely reduced, owing to the great capital outlay needed for hydraulic works. There is, then, little doubt that the present cost of aluminium, about eighteenpence a pound, represents roughly the lowest figure at which the Hall and Héroult processes can profitably be worked. With a density 30 per cent., and a conductivity 60 per cent. that of copper, pure aluminium conductors can transmit the same electrical energy over a given distance with only half the weight of metal. As an electrical conductor, therefore, aluminium at eighteenpence is equivalent to copper at ninepence a pound, or 84*l.* a ton, a figure considerably below what it lately reached.

It is curious to observe how entirely dependent the electrical engineering industry is upon the price and the conductivity of copper. The former largely determines the degree of success, or at all events the method of carrying out, of electrical power transmission schemes; while the latter, in conjunction with the permeability of iron, actually decides the scale upon which our electrical machinery must be built, since the output or effort for a given speed of running is always limited by the heating which occurs; and this, at full load, arises mainly from the imperfect electrical conductivity of copper.

Aluminium offers, it is true, no prospect of reduced

size of our machinery, owing to its bulk (*diameter* nearly 30 per cent. greater than equivalent copper); but it will now always act as a check upon the artificial raising of the price of copper.

The high cost of insulating materials renders it unlikely that aluminium with its greater size will ever replace copper in insulated cables. And even as a bare conductor, it is doubtful what advantage in price (together with whatever saving may come from having wires only half as heavy to handle and support) will compensate for the many disadvantages as compared with hard-drawn copper—greater liability to corrosion, difficulty of making joints, less tensile strength (even of aluminium bronze), lack of uniform quality, greater surface exposed to the wind, greater unsightliness owing to size (for trolley wires), &c.

Still, the excessive price of copper which has obtained during the last two years, and indeed till a few months ago, has led to the putting down of between one and two thousand tons of bare aluminium conductors for electric-power transmission—chiefly in America, and for very high-tension, long-distance schemes—schemes, in fact, in which the cost of the lines represents the greatest proportion of the whole expenditure.

The experience as to the behaviour of aluminium already gained from these installations is very valuable, as may be gathered from a perusal of two recent papers—one read by Messrs. Perrine and Baum before the American Institution of Electrical Engineers, and the other by Mr. Kershaw before our own similar Institution. The former writers find that, owing to a large temperature change in the elastic constant, the true coefficient of expansion of the new metal is not applicable in calculations of stresses in suspended wires having a given sag, the apparent temperature effects being much less than those calculated. Again, in the latter paper it is suggested that aluminium will not weather so well in this country as in the drier climate of America. It would seem also as if, while good soldered joints are quite possible with the metal, only welded or "burnt" joints involving no solder are durable out-of-doors, the metal being so highly electropositive, and the alloys formed near soldered joints unstable. Mechanical joints are generally used in America. The McIntyre joint is made by slipping the ends into a flat aluminium sleeve, the whole being then twisted round twice or thrice. It is doubtful whether such joints retain their initial high conductivity, in view of experience with similar joints in telegraph work. As an electrical conductor, then, it is only in those rare cases where conducting power for a given weight is wanted, *irrespective of volume*, that aluminium is without question the best material to use.

For structural purposes, the new metal has up to the present proved a little disappointing. In the first place, the pure metal is useless, being too soft. This, however, was to be expected. Pure iron is also soft. The alloys with copper up to a density of 3 include some which seem fairly strong; but the fact that cycle frames are still made of steel shows that, where strength and lightness are required together, and cost is not of great moment, steel can still hold its own, apart from its relative cheapness. No doubt, however, there is yet much to be learnt about the metallurgy of the alloys with copper, and with other elements also—nickel, tin, magnesium, &c.

A considerable demand for aluminium has grown up in connection with the manufacture of a great variety of small articles, instruments, &c. The most important uses of the metal from a commercial point of view are based upon the activity of its reactions at a high temperature. Added in small quantities to molten iron just before a cast is made, the metal is rendered more fluid and the quality of the casting thereby improved.<sup>1</sup> This

result appears to be due to the reduction by the aluminium of any iron oxide which may be present, and to the raising of temperature of the iron itself by the heat of the action. It was stated by Swan, in a recent presidential address in Glasgow, that this use of the metal formed one of the chief outlets for the 6000 odd tons of aluminium which were manufactured last year.

The Goldschmidt process, by which the most intense heat can be produced in any required amount at a given point also depends upon the same fact, that aluminium can reduce iron oxide with energy to spare. A mixture of finely-divided aluminium and iron oxide, known as "thermit," can be ignited by a suitable fuse, and results in a quantity of molten iron heated far above the melting-point and protected from combustion by a layer of alumina. This iron, being so very greatly superheated, will serve for a variety of purposes, and its quality can be varied as required by suitable additions to the "thermit." This process was lately described and demonstrated at the Royal Institution by Roberts-Austen,<sup>1</sup> to whom, indeed, it is largely due. It has been applied to the welding of rail joints in position for electric traction, and to the repairing of broken and of faulty steel castings. The process has, in fact, many of the possibilities of the electric furnace, without the drawback of being dependent upon a fixed and costly electrical installation.

#### THE OCTOBER ORIONIDS.

IN many previous years the Orionid radiant has been well defined at a point very close to, if not coinciding with, the position of the star  $\nu$  Orionis (mag. 4½). The shower was very successfully observed by Prof. A. S. Herschel on about October 18–20 in the years 1864, 1865 and 1867, when the centre of divergence was found to be at  $90^\circ + 15^\circ$ . A number of observations were obtained at Bristol in 1877, 1879, 1887 and other years, and the radiant derived from them was at  $91^\circ + 15^\circ$ . The meteors of this shower belong to the swifter class, and they leave streaks which enable their directions of flight to be so correctly noted that the centre of emanation not only appears sharply defined, but can be very accurately located. The streaks frequently linger for two or three seconds and will sometimes very perceptibly brighten up after the heads of the meteors have vanished.

The observations in 1900 and 1901 made at Bristol show that the true Orionids were feebly represented and that, in fact, the annual shower-meteors from the old position at  $\nu$  Orionis had been supplanted by a more active radiant of Geminids agreeing in place with the star  $\xi$  Geminorum (mag. 3½). On October 23–27, 1900, and October 20, 1901, I recorded about twice as many meteors from  $100^\circ + 13^\circ$  as from  $91^\circ + 15^\circ$ . The observations were not very numerous, but had they been far more complete there is no reason to suppose that the conclusions would have been materially affected.

The difference of  $9^\circ$  in the positions of the radiants at  $\nu$  and  $\xi$  Orionis is sufficiently large to be immediately detected by meteoric observers though their materials are merely eye estimations. The latter are, however, unusually trustworthy, not only in the case of the Orionid display, but also in regard to some of its bordering and contemporary showers which furnish similar objects. The flash of a meteor's head as it darts rapidly along in a state of combustion attracts the eye to the point of appearance, and the streak which immediately glows along the path enables the observer to fix the apparent direction of flight with almost instrumental precision.

In the *Monthly Notices* for December 1895 (vol. lvi. p. 74) I mentioned the  $\gamma$  Geminids as one of the most prominent companion radiants of the Orionids and gave

<sup>1</sup> See "The Relations of Aluminium to Iron," by Godfrey Melland (*Proc. Staff. Iron and Steel Inst.*, 1900).

<sup>1</sup> "Metals as Fuel," Royal Institution Lecture (*NATURE*, August 8, 1901).